09-2700 A

Practitioner's Docket No. 80113-0070 *PATENT*

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of
Inventor(s): **Kevin Lynaugh, Michael A. Grossman and Yong Huang Zeng**

For (title): **METHOD AND SYSTEM FOR ESTIMATING INPUT POWER IN A CABLE MODEM NETWORK**

1. Type of Application

This new application is for a(n)

- ☒ Original (nonprovisional)
- ☐ Design
- ☐ Plant
- ☐ Divisional.
- ☐ Continuation.
- ☐ Continuation-in-part (C-I-P).

CERTIFICATION UNDER 37 C.F.R. 1.10*
*(Express Mail label number is **mandatory**.)*
(Express Mail certification is optional.)

I hereby certify that this correspondence and the documents referred to as attached therein are being deposited with the United States Postal Service on this date 09/26/2000, in an envelope as "Express Mail Post Office to Addressee," mailing Label Number **EL 429 915 111 US**, addressed to the: Box Patent Application, Assistant Commissioner for Patents, Washington, D.C. 20231.

Janice E. Laurro
(type or print name of person mailing paper)
Janice E. Laurro
Signature of person mailing paper

2. **Benefit of Prior U.S. Application(s)** (35 U.S.C. 119(e), 120, or 121)

☒ The new application being transmitted claims the benefit of prior U.S. application(s). Enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

3. **Papers Enclosed**

A. Required for Filing Date under 37 C.F.R. § 1.53(b) (Regular) or 37 C.F.R. § 1.153 (Design) Application

10 Pages of Specification
06 Pages of Claims
05 Sheets of Drawing
- ☐ Formal
- ☒ Informal

☐ The enclosed drawing(s) are photograph(s), and there is also attached a "PETITION TO ACCEPT PHOTOGRAPH(S) AS DRAWING(S)." 37 C.F.R. § 1.84(b).

B. Other Papers Enclosed

_____ Pages of declaration and power of attorney
01 Pages of Abstract
_____ Other

4. **Additional Papers Enclosed**

☐ Amendment to claims
- ☐ Cancel in this applications claims _____ before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)
- ☐ Add the claims shown on the attached amendment. (Claims added have been numbered consecutively following the highest numbered original claims.)

☐ Preliminary Amendment
☐ Information Disclosure Statement (37 C.F.R. § 1.98)
☐ Form PTO-1449 (PTO/SB/08A and 08B)
☐ Citations
☐ Declaration of Biological Deposit
☐ Submission of "Sequence Listing," computer readable copy and/or amendment pertaining thereto for biotechnology invention containing nucleotide and/or amino acid sequence.
☐ Authorization of Attorney(s) to Accept and Follow Instructions from Representative
☐ Special Comments
☐ Other

5. Declaration or Oath (including power of attorney)

☐ Enclosed
Executed by
- ☐ inventor(s).
- ☐ legal representative of inventor(s). 37 C.F.R. § 1.42 or 1.43.
- ☐ joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached.
  - ☐ This is the petition required by 37 C.F.R. § 1.47 and the statement required by 37 C.F.R. § 1.47 is also attached. See item 13 below for fee.

☒ Not Enclosed.
- ☐ Application is made by a person authorized under 37 C.F.R. 1.41(c) on behalf of *all* the above named inventor(s).
  - ☐ Showing that the filing is authorized.
    (not required unless called into question. 37 C.F.R. § 1.41(d))

6. Inventorship Statement

The inventorship for all the claims in this application are:

☐ The same.

or

☐ Not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made,
- ☐ is submitted.
- ☐ will be submitted.

7. Language

☒ English
☐ Non-English
- ☐ The attached translation includes a statement that the translation is accurate. 37 C.F.R. § 1.52(d).

8. Assignment

☐ An assignment of the invention to
- ☐ is attached. A separate ☐ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or [ ] FORM PTO 1595 is also attached.
- ☐ will follow.

9. Certified Copy

Certified copy(ies) of application(s)

country	appln. no.	filed
country	appln. no.	filed
country	appln. no.	filed

from which priority is claimed

☐ is (are) attached.
☐ will follow.

10. Fee Calculation (37 C.F.R. § 1.16)

A. ☒ Regular application

CLAIMS AS FILED			
Number Filed	Number Extra	Rate	Basic Fee 37 CFR 1.16(a) $ 690.00
Total Claims (37 CFR 1.16(c)	24 -20 = 04	X $ 18.00	72.00
Independent Claims (37 CFR 1.16(b))	03 - 3 = 00	X $ 78.00	
Multiple dependent claims, if any, (37 CFR 1.16(d))		X $ 260.00	

☐ Amendment cancelling extra claims is enclosed.
☐ Amendment deleting multiple-dependencies is enclosed.
☐ Fee for extra claims is not being paid at this time.

Filing Fee Calculation $ **762.00**

B. ☐ Design application
($310.00—37 C.F.R. § 1.16(f))

Filing Fee Calculation $_____

C. ☐ Plant application
($480.00—37 C.F.R. § 1.16(g))

Filing Fee Calculation $_____

11. Small Entity Statement(s)

☐ Statement(s) that this is a filing by a small entity under 37 C.F.R. §§ 1.9 and 1.27 is (are) attached.

☐ Status as a small entity was claimed in prior application _____, filed on _____ from which benefit is being claimed for this application under:

35 U.S.C. §
- ☐ 119(e),
- ☐ 120,
- ☐ 121,
- ☐ 365(c),

and which status as a small entity is still proper and desired.

☐ A copy of the statement in the prior application is included.

Filing Fee Calculation (50% of **A**, **B** or **C** above) $_____

12. Request for International-Type Search (37 C.F.R. § 1.104(d))

☐ Please prepare an international-type search report for this application at the time when national examination on the merits takes place.

13. Fee Payment Being Made at This Time

☐ Not Enclosed

☐ No filing fee is to be paid at this time.
(This and the surcharge required by 37 C.F.R. § 1.16(e) can be paid subsequently.)

☒ Enclosed

☒	Filing fee	$ **762.00**
☐	Recording assignment ($40.00; 37 C.F.R. § 1.21(h)) (See attached "COVER SHEET FOR ASSIGNMENT ACCOMPANYING NEW APPLICATION.")	$_____
☐	Petition fee for filing by other than all the inventors or person on behalf of the inventor where inventor refused to sign or cannot be reached ($130.00; 37 C.F.R. §§ 1.47 and 1.17(i))	$_____
☐	For processing an application with a specification in a non-English language ($130.00; 37 C.F.R. §§ 1.52(d) and 1.17(k))	$_____
☐	Processing and retention fee ($130.00; 37 C.F.R. §§ 1.53(d) and 1.21(l))	$_____
☐	Fee for international-type search report ($40.00; 37 C.F.R. § 1.21(e))	$_____
	Total Fees Enclosed	$_____

14. Method of Payment of Fees

☐ Check in the amount of $_____.

☒ Charge Account No. **18-0013** in the amount of $ **762.00** .

A duplicate of this transmittal is attached.

15. Authorization to Charge Additional Fees

☒ The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No. **18-0013**.

- ☒ 37 C.F.R. § 1.16(a), (f) or (g) (filing fees)
- ☒ 37 C.F.R. § 1.16(b), (c) and (d) (presentation of extra claims)
- ☒ 37 C.F.R. § 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)
- ☒ 37 C.F.R. § 1.17(a)(1)-(5) (extension fees pursuant to § 1.136(a).
- ☒ 37 C.F.R. § 1.17 (application processing fees)
- ☐ 37 C.F.R. § 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. § 1.311(b))

16. Instructions as to Overpayment

☒ Credit Account No. **18-0013**.
☐ Refund.

Date: 26 September 2000

SIGNATURE OF PRACTITIONER

Reg. No. 36,372

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☒ **Incorporation by reference of added pages**

- ☒ Plus Added Pages for New Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed
  Number of pages added **03**
- ☐ Plus Added Pages for Papers Referred to in Item 4 Above
  Number of pages added _____
- ☐ Plus added pages deleting names of inventor(s) named on prior application(s) who is/are no longer inventor(s) of the subject matter claimed in this application.
  Number of pages added _____
- ☐ Plus "Assignment Cover Letter Accompanying New Application"
  Number of pages added _____

☐ **Statement Where No Further Pages Added**

☐ This transmittal ends with this page.

R0094229

ADDED PAGES FOR APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED

17. Relate Back

☒ Amend the specification by inserting, before the first line, the following sentence:

A. 35 U.S.C. 119(e)

☒ "This application claims the benefit of U.S. Provisional Application(s) No(s).:

APPLICATION NO(S).:	**FILING DATE**
60/155,802	**09/27/99**

B. 35 U.S.C. 120, 121 and 365(c)

☐ "This application is a

- ☐ continuation
- ☐ continuation-in-part
- ☐ divisional

of copending application(s)

☐ application number _____ filed on _____"
☐ International Application _____ filed on _____ and which designated the U.S."
☐ "The nonprovisional application designated above, namely application _____, filed _____, claims the benefit of U.S. Provisional Application(s) No(s).:

APPLICATION NO(S).:	**FILING DATE**

☐ Where more than one reference is made above please combine all references into one sentence.

18. Relate Back—35 U.S.C. 119 Priority Claim for Prior Application

The prior U.S. application(s), including any prior International Application designating the U.S., identified above in item 17B, in turn itself claim(s) foreign priority(ies) as follows:

Country	Appln. no.	Filed

The certified copy(ies) has (have)

☐ been filed on _____, in prior application _____, which was filed on _____.
☐ is (are) attached.

19. Maintenance of Copendency of Prior Application

A. ☐ Extension of time in prior application

*(This item **must** be completed and the papers filed **in the prior application,** if the period set in the prior application has run.)*

☐ A petition, fee and response extends the term in the pending **prior** application until _____
☐ A **copy** of the petition filed in prior application is attached.

B. ☐ Conditional Petition for Extension of Time in Prior Application

(complete this item, if previous item not applicable)

☐ A conditional petition for extension of time is being filed in the pending **prior** application.
☐ **A copy** of the conditional petition filed in the prior application is attached.

20. Further Inventorship Statement Where Benefit of Prior Application(s) Claimed
(complete applicable item (a), (b) and/or (c) below)

(a) ☐ This application discloses and claims only subject matter disclosed in the prior application whose particulars are set out above and the inventor(s) in this application are
☐ the same.
☐ less than those named in the prior application. It is requested that the following inventor(s) identified for the prior application be deleted:

_____
(type name(s) of inventor(s) to be deleted)

(b) ☐ This application discloses and claims additional disclosure by amendment and a new declaration or oath is being filed. With respect to the prior application, the inventor(s) in this application are

☐ the same.
☐ the following additional inventor(s) have been added:

_____
(type name(s) of inventor(s) to be deleted)

(c) ☐ The inventorship for all the claims in this application are

☐ the same.
☐ not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made
☐ is submitted.
☐ will be submitted.

21. Abandonment of Prior Application *(if applicable)*

☐ Please abandon the prior application at a time while the prior application is pending, or when the petition for extension of time or to revive in that application is granted, and when this application is granted a filing date, so as to make this application copending with said prior application.

22. Petition for Suspension of Prosecution for the Time Necessary to File an Amendment

☐ There is provided herewith a Petition To Suspend Prosecution for the Time Necessary to File An Amendment (New Application Filed Concurrently)

23. Small Entity (37 CFR § 1.28(a))

☐ Applicant has established small entity status by the filing of a statement in parent application _____ on _____.

☐ A copy of the statement previously filed is included.

24. NOTIFICATION IN PARENT APPLICATION OF THIS FILING

☐ A notification of the filing of this
(check one of the following)

☐ continuation
☐ continuation-in-part
☐ divisional

is being filed in the parent application, from which this application claims priority under 35 U.S.C. § 120.

r0069998

METHOD AND SYSTEM FOR ESTIMATING INPUT POWER IN A CABLE MODEM NETWORK

TECHNICAL FIELD

The present invention relates to cable modem networks, and more particularly to input power estimation methods that compensate for variations in tuner gain characteristics.

BACKGROUND ART

Digital modems are increasingly being used by consumers as cable modem network service providers obtain additional subscribers. Cable modem devices designed for the mass-market are designed to be affordable to as many consumers as possible. However, low-cost, high production devices manufactured for the mass consumer market often exhibit variations and irregularities in their operating characteristics, such as gain non-linearities, frequency ripple and temperature effects. These variations make it difficult to measure the radio frequency (RF) input power to the cable modem accurately.

Currently known calibration solutions do not address variations in the tuner gain and intermediate frequency (IF) amplifier gain in the tuner of the cable modem as the frequency and power level of the input signal changes. Further, any calibration method that applies the same parameters globally to all cable modem devices do not consider the fact that individual devices may exhibit slightly different operating characteristics and may have different irregularities. These variations may adversely affect the cable

modem's performance if not adequately addressed via an accurate input RF power determination.

Although it is theoretically possible to use the cable modem to calculate data that will compensate for variations in tuner gain characteristics, this would require incorporating additional calculation circuitry into the cable modem, increasing the cable modem's complexity and generating a device that is likely to be too expensive for the mass consumer market.

There is a need for a simple method and system to correct for variations and irregularities that are commonly encountered in low-cost, high volume cable modems when estimating input power to the cable modem.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a method for estimating input power to a cable modem device having a tuner and a modem. The method includes generating a look-up table that contains look-up values used to compute an estimated input power to the modem's receiver. The look-up table is stored in the modem for reference. The method includes inputting a plurality of calibration signals having known input frequencies and known input power levels into the device's receiver, recording a calibration point corresponding to each of said plurality of signals in a calibration matrix, and connecting the calibration points in said calibration matrix to generate the look-up table values.

A cable modem device according to the claimed invention has the look-up table stored in the modem, preferably as 8-bit data. During modem operation, the modem checks the frequency and amplitude of an input signal received by the modem's receiver, checks the look-up table for the look-up value corresponding to the frequency and amplitude, and uses the look-up value to determine an estimated input power. Because the look-up table values are derived from the cable modem device's actual operating characteristics, the input power estimate will reflect any variations or irregularities in the specific device being used.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a representative block diagram illustrating an automatic gain control loop that is used in conjunction with the inventive method;

Figure 2 is a flowchart illustrating one embodiment of the inventive method;

Figure 3a and 3b illustrate an example of generating amplitude points in a look-up table from calibration data;

Figures 4a and 4b illustrate an example of generating frequency points in a look-up table from calibration data;

Figure 5 is a graphical representation of calibration data according to the present invention; and

Figure 6 is a graphical representation of a look-up table according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 is a block diagram representing an automatic gain control (AGC) circuit that is used to generate information to be used for computing input RF power. The AGC circuit 100 is found in the integrated circuit of known digital modems. The AGC circuit 100 includes a power detector 102, a loop filter having gain G(s) 104, and a variable gain device 106, such as a voltage variable amplifier, as well as an adder/subtractor 108 located at input of the filter 104. The AGC circuit 100 is used to adjust the gains of the receiver and intermediate frequency (IF) stages of the tuner in the cable modem to maintain a constant receiver power output. As can be seen in the Figure, the AGC circuit 100 has a closed loop, negative feedback control system configuration, which ensures that the power output of the receiver remains constant.

The relationship between the power out of the receiver of the AGC circuit 100, $P_{demod}(dBm)$ and the input power $P_{input}(dBm)$ can be generally defined as follows:

$$P_{Demod}\,(dBm) = P_{INPUT}\,(dBm) + G_{Receiver}(dB) \qquad (1)$$

If a voltage variable amplifier is used as the variable gain device 106, the expression for the receiver output power can be as follows:

$$P_{Demod}(dBm) = P_{INPUT}(dBm) + V_{AGC}(V/dB) \bullet K_{VVA}\,(dB/Volt) + G_{Receiver}\,(dB) \qquad (2)$$

One specific embodiment, to be used in a digital AGC circuit implementation, is to use digital integrators for accumulating the AGC error signals. The accumulated value of the AGC's integrator register is proportional to the voltage applied to the voltage variable gain device 106 once the loop has reached equilibrium, as indicated by the following expression:

$$V_{AGC}(V/dB) \propto \Psi_{IntAccumValue}(bits) \bullet K_{\Sigma\Delta}(Volts/Bits) \quad (3)$$

Combining the information in Equations 2 and 3 results in the following expression:

$$P_{Demod}(dBm) = P_{INPUT}(dBm) + \Psi_{IntAccumValue}(bits) \bullet K_{\Sigma\Delta}(Volts/Bits) \bullet K_{VVA}(dB/Volt) + G_{Receiver}(dB) \quad (4)$$

As can be seen in Equation 4, the input power P_{input}(dBm) of the receiver can be obtained for any given accumulated value of the AGC integrator Ψ_{acc}.

The specific manner in which the accumulated value in the AGC integrator is used to compute the receiver's input power will be explained with reference to Figure 2. Figure 2 is a flowchart that illustrates one embodiment of the inventive method 200. As noted above, the inventive method uses the AGC integrator's accumulated value and estimates the input RF power using an algorithm and look-up table. The look-up table itself is preferably generated during a production phase, after the digital modem and tuner

in the cable modem device have already been manufactured and connected together. During the production phase, a selected number of sample signals having a known power level and frequency are applied to the tuner input at step 202. Each sample signal will act as a sample point for generating a calibration matrix corresponding with that specific cable modem device. Preferably, the sample points include multiple power levels over the same frequency as well as multiple frequencies for the same power level. Of course, if greater accuracy is desired, more sample points can be taken, but doing so will increase the time and expense required for calibration.

Next, the tuner in the cable modem device tunes to each sample signal at step 204 and the AGC loop adjusts the gain of the tuner at step 206 for each signal. For each sample point, the input power Pin, input frequency Fin, and the AGC integrator accumulated value Ψ_{acc} are recorded at step 208. For explanatory purposes, the term "Na" refers to amplitude points in the matrix (with "Na_cal" referring to amplitude points obtained during calibration) and the term "Nf" refers to frequency points (with "Nf_cal" referring to frequency points used during calibration). The calibration points are preferably taken over a large frequency and amplitude range to ensure that the sample points reflect the device's operating characteristics. For example, the inventive method may obtain nine amplitude samples (Na_cal = 9) over 27 dB and ten calibration frequencies (Nf_cal=10) over 764 MHz.

After the calibration data has been obtained and recorded, the inventive method generates a look-up table corresponding to the specific cable modem device at step 210 from the calibration data. Examples of how data in the look-up table is generated are

shown in Figures 3a and 3b (amplitude) and Figures 4a and 4b (frequency). The objective of the look-up table is to provide a look-up value for each channel frequency and amplitude value that may be encountered by the cable modem. The specific amount of data in the look-up table can vary depend on the desired resolution. For example, using the example above, if the desired resolution includes a data point every 1 dB of amplitude and every 6 MHz of frequency, the final look-up table will be a matrix having dimensions Na = 31 points by Nf = 134 points.

To calculate the values for the look-up table from the calibration points, the method includes interpolating between the AGC integrator accumulated Ψ_{acc} for selected amplitude points at a selected frequency during step 210. An example is illustrated in Figures 3a and 3b. The interpolation itself can be conducted using a first or second order equation to fit a curve along the calibration data points to reduce RMS errors. Other interpolation and calibration techniques for linking the calibration points include using an audio tone to reduce the calibration errors caused by modulated signal fluctuations. For multi-band receivers, the inventive method may localize the calibration slope to reduce errors even further. Also, the calibration data can be fitted to known voltage variable amplifier curves to reduce the number of calibration points needed to obtain values for the components' RF tuner gains and IF gain amplifiers. Similarly, additional frequency points can be obtained via interpolation and extrapolation, as shown in Figures 4a and 4b, and stored in the look-up table.

After all of the desired points have been generated from interpolating and extrapolating the calibration data, the resulting look-up table preferably contains one

AGC integrator accumulator value data point for each amplitude and frequency value in the tuner's operating range. When a user wishes to measure the input RF power to the modem's receiver, the AGC integrator accumulator value Ψ_{acc} corresponding to the tuner's frequency is read from the look-up table and used to estimate the input power from Equation 4 above. Because the AGC integrator accumulator value is calculated from a value obtained via the modem's actual operating characteristics, the values in the look-up table will reflect and compensate for any variations in the particular device's characteristics, such as gain non-linearity, frequency ripple, or temperature effects, in the input power calculation.

Figures 5 and 6 are three-dimensional graphical representations of the data generated and used by the inventive method. Figure 5 is an example of a calibration table for a specific cable modem, while Figure 6 is an example of a look-up table that is stored in the cable modem. As can be seen in the Figures, Figure 6 provides a finer, more detailed representation of the plot shown in Figure 5, which primarily acts as a framework for the look-up table. When the user wishes to measure the input RF power to the receiver, the AGC integrator accumulator value Ψ_{acc} corresponding to the tuner's frequency and amplitude is read from the look-up table, such as the one shown in Figure 5, and is used to calculate an estimated input RF power value as explained above. If desired, the dynamic range of the look-up table can be rescaled to accommodate a greater range frequency and/or amplitude values by setting maximum and minimum values for the look-up table.

To save digital memory, the look-up table values are preferably normalized to 8-bits to conserve memory space. The maximum and minimum values can be used to scale the stored 8-bit values to their actual AGC integrator accumulator values Ψ_{acc}.

As a result, the inventive system does not require any calculations to be conducted in the digital modem itself. Instead, the invention uses AGC accumulator register values in a digital demodulator to estimate input RF power using a simple algorithm and a look-up table, using external test equipment to generate the look-up table data stored in the modem. The data in the look-up table is preferably generated externally by interpolating and/or extrapolating points from sparse calibration data and stored in the modem using a compact format (e.g., 8-bit data). During operation, the modem simply references the data corresponding to the input frequency and amplitude in the look-up table to obtain an associated AGC integrator accumulator value. The accumulator value is then used to calculate the input RF power of the receiver. Because the AGC integrator accumulator values in the look-up table are interpolated from the actual, device-specific operating characteristics of the tuner in the cable modem device, the inventive method
The inventive system therefore can compensate for gain non-linearity, frequency ripple and temperature effects often found in low-cost RF tuners by including data corresponding to these effects in the look-up table, without requiring an excessive number of calibration points to generate the look-up table data.

It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended

that the following claims define the scope of the invention and that the method and apparatus within the scope of these claims and their equivalents be covered thereby.

CLAIMS

1. A method for estimating input power in a cable modem device having a tuner and a modem, the modem having a receiver with an automatic gain control (AGC) circuit, the method comprising the steps of:

inputting a plurality of calibration signals having known input frequencies and known input power levels into the receiver;

recording a calibration point corresponding to each of said plurality of signals in a calibration matrix;

connecting the calibration points in said calibration matrix to generate look-up table values stored in a look-up table; and

storing the look-up table in the modem, wherein said look-up table values are used to compute input power to the receiver.

2. The method of claim 1, wherein the calibration point in the recording step is an accumulated value of an integrator in the AGC circuit.

3. The method of claim 2, wherein the look-up table values are a plurality of accumulated values of an integrator in the AGC circuit, each of said plurality of accumulated values corresponding with a single frequency and a single amplitude.

4. The method of claim 1, wherein the recording step records at least one selected from the group consisting of the input frequency of the calibration signal, the

input power of the calibration signal, and an accumulated value of an integrator in the AGC circuit as the calibration point.

5. The method of claim 1, wherein the connecting step includes interpolating between the calibration points.

6. The method of claim 5, wherein the interpolating step is conducted using a first order equation.

7. The method of claim 5, wherein the interpolating step is conducted using a second order equation.

8. The method of claim 5, wherein the interpolating step is conducted using an audio tone.

9. The method of claim 5, wherein the interpolating step is conducted using a known voltage variable amplifier curve.

10. The method of claim 1, wherein the connecting step includes the step of interpolating between the calibration points, and wherein the method further comprises the step of extrapolating beyond the range of the calibration points.

11. The method of claim 10, wherein the extrapolation step is conducted using linear projection from a localized amplitude corresponding to a selected calibration frequency.

12. The method of claim 11, wherein the extrapolation step is repeated for each calibration frequency.

13. The method of claim 1, wherein the storing step stores the look-up table as 8-bit data.

14. The method of claim 13, wherein the storing step also stores a maximum value and a minimum value for the frequency and the amplitude, wherein said maximum and minimum values are used to scale the 8-bit data.

15. A method for estimating input power in a cable modem device having a tuner and a modem, the modem having a receiver with an automatic gain control (AGC) circuit, the method comprising the steps of:

inputting a plurality of calibration signals having known input frequencies and known input power levels into the receiver;

recording an accumulated value in an integrator in the AGC corresponding to each of said plurality of calibration signals as a calibration point in a calibration matrix;

interpolating between the calibration points and extrapolating from the calibration points in said calibration matrix to generate look-up table values stored in a look-up table; and

storing the look-up table in the modem, wherein said look-up table values are used to compute input power to the receiver.

16. The method of claim 15, wherein the interpolation step is conducted using a first order algorithm.

17. The method of claim 16, wherein the interpolation step is conducted using a second order algorithm.

18. The method of claim 15, wherein the interpolating step is conducted using an audio tone.

19. The method of claim 15, wherein the interpolating step is conducted using a known voltage variable amplifier curve.

20. The method of claim 15, wherein the look-up table values are stored as 8-bit data.

21. The method of claim 15, wherein the storing step also stores a maximum value and a minimum value for the frequency and the amplitude, wherein said maximum and minimum values are used to scale the 8-bit data.

22. A cable modem device, comprising:

a tuner that tunes to an input signal;

a modem coupled to the tuner, the modem having a receiver with an automatic gain control (AGC) circuit and a memory; and

a look-up table stored in the memory, the look-up table containing a plurality of look-up table values generated by inputting a plurality of calibration signals having known input frequencies and known input power levels into the receiver; recording an accumulated value in an integrator in the AGC corresponding to each of said plurality of calibration signals as a calibration point in a calibration matrix, and interpolating between the calibration points and extrapolating from the calibration points in said calibration matrix to generate the look-up table values,

wherein said look-up table values are used to compute input power to the receiver.

23. The cable modem device of claim 22, wherein the look-up table values are stored in the memory as 8-bit data.

24. The cable modem device of claim 23, wherein the memory also contains a maximum value and a minimum value for the frequency and the amplitude, wherein said maximum and minimum values are used to scale the 8-bit data.

ABSTRACT

A method for estimating the input power to a cable modem includes generating a look-up table containing AGC integrator accumulator values corresponding to selected frequencies and amplitudes. The look-up table is generated by first constructing a calibration matrix by inputting a plurality of calibration signals having known input frequencies and known input power levels into the cable modem's receiver, and recording AGC integrator accumulator values corresponding to several frequencies and power levels over a selected operating range as calibration points. Next, an interpolation and extrapolation process generates the look-up values corresponding to the frequencies and amplitudes in between the calibration points. During modem operation, the modem estimates the input power by checking the AGC integrator accumulator value corresponding to the input frequency and amplitude. Because the look-up table values are based on the cable modem's actual operating characteristics, the estimated input power will reflect any variations or irregularities in the modem's operation, such as gain non-linearities, frequency ripple, or temperature effects.

R0093497

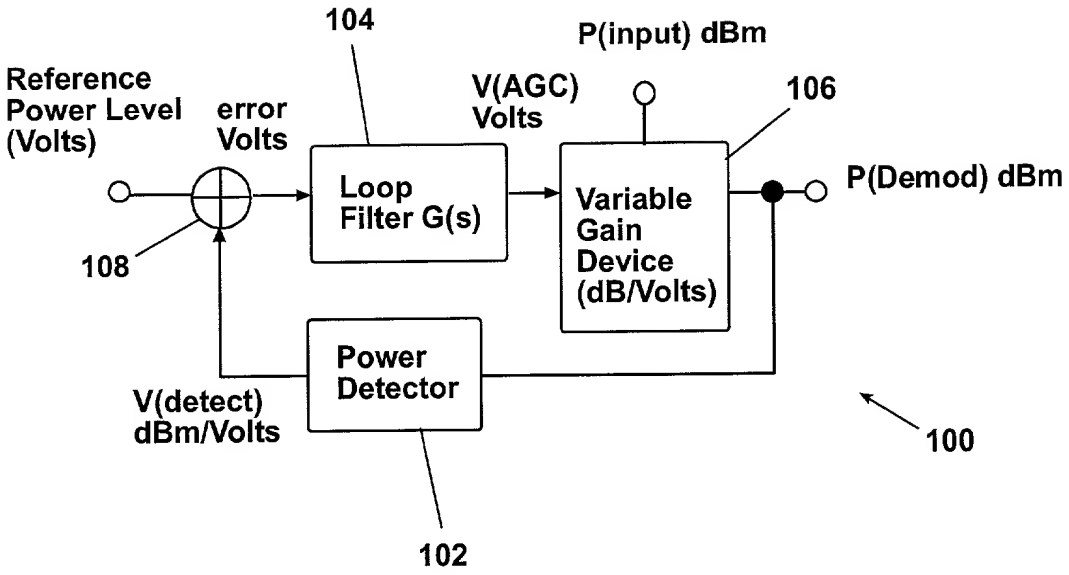

104
P(input) dBm
Reference
Power Level
(Volts)
error
Volts
V(AGC)
Volts
106
Loop
Filter G(s)
Variable
Gain
Device
(dB/Volts)
P(Demod) dBm
108
Power
Detector
V(detect)
dBm/Volts
100
102

Fig. 1

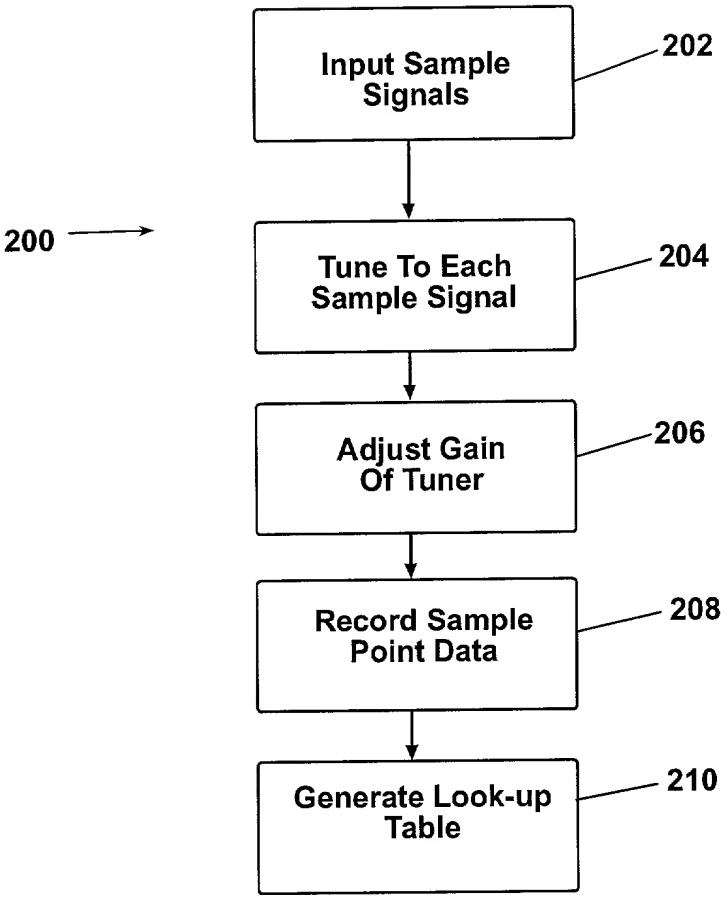

200
Input Sample Signals
202
Tune To Each Sample Signal
204
Adjust Gain Of Tuner
206
Record Sample Point Data
208
Generate Look-up Table
210

Fig. 2

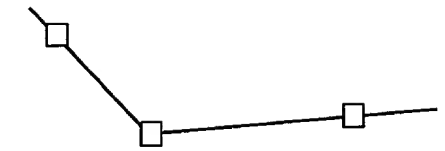


Fig. 3A

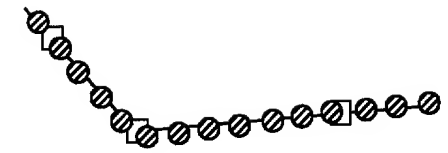


Fig. 3B

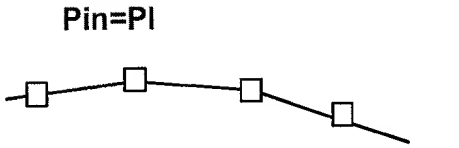


Fig. 4A

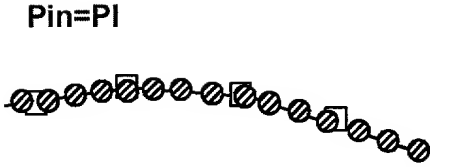
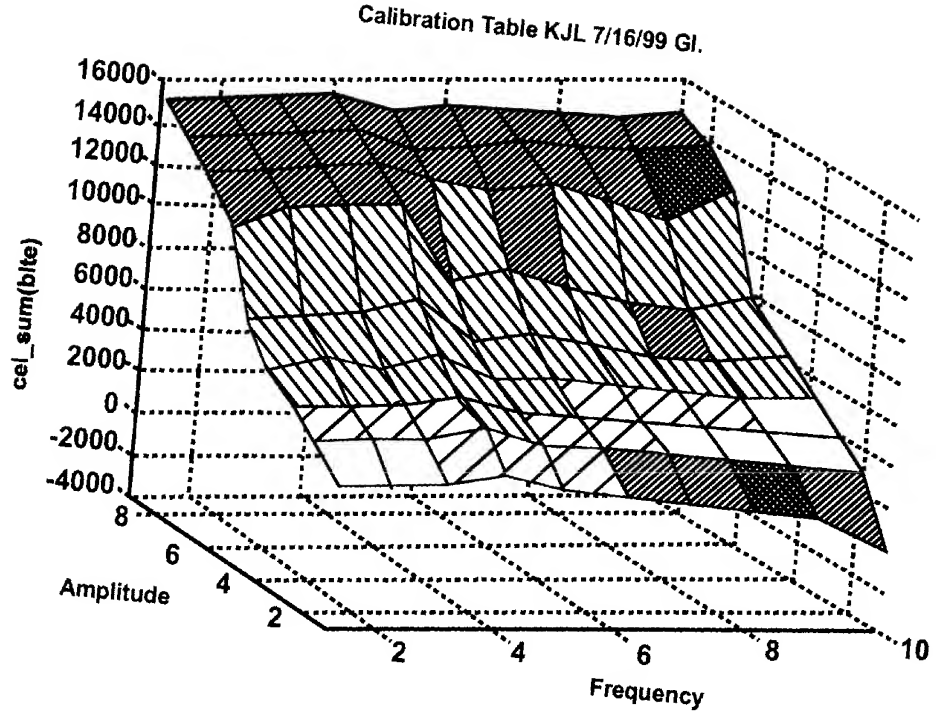
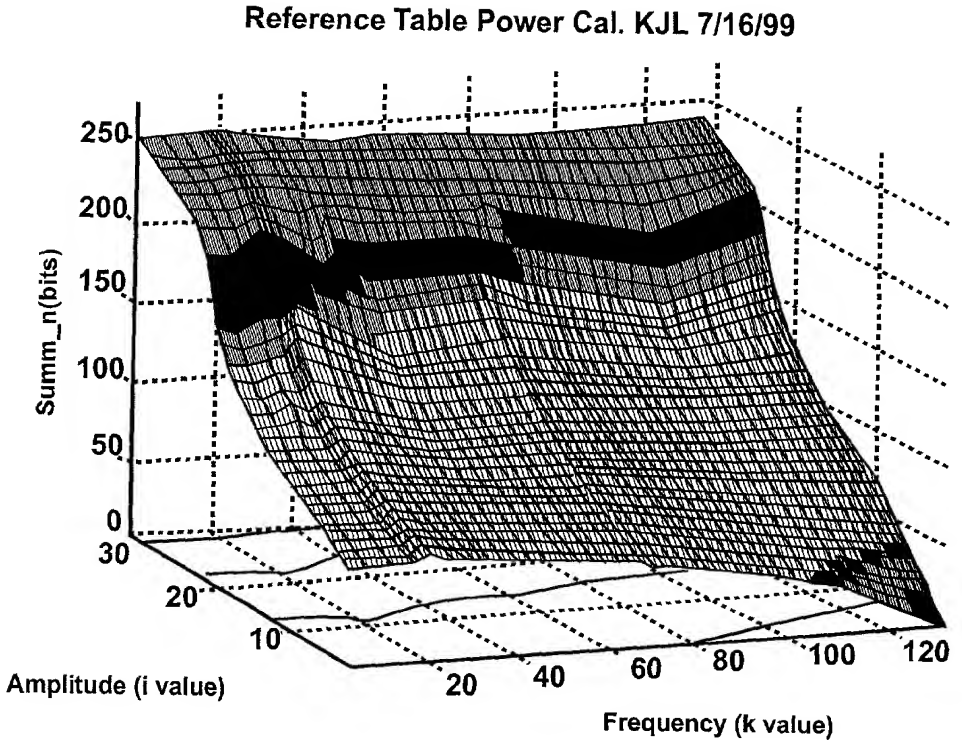


Fig. 4B



Calibration Table, Na_cal=9, Nf_cal=10

Fig. 5



Cable Modem Implementation of Look-Up-Table Na=31, Nf=134

Fig. 6